Quantitative Ballistic Electron Magnetic Microscopy: magnetic imaging of buried nanostructures with a sub-nanometric lateral resolution

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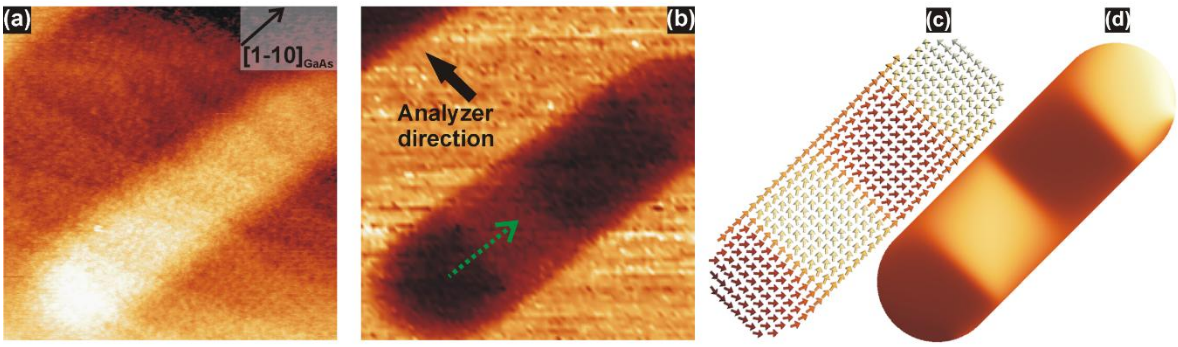
We demonstrate quantitative ballistic electron magnetic microscopy (BEMM) imaging of simple model Fe(001) nanostructures. We use in situ nanostencil shadow mask resistless patterning combined with molecular beam epitaxy deposition to prepare under ultra-high vacuum conditions nanostructured epitaxial Fe/Au/Fe/GaAs(001) spin-valves. In this epitaxial system, the magnetization of the bottom Fe/GaAs(001) electrode is parallel to the [110] direction, defining accurately the analysis direction for the BEMM experiments. The large hot-electron magnetoresistance of the Fe/Au/Fe/GaAs(001) epitaxial spin-valve [1] allows us to image various stable magnetic configurations on the as-grown Fe(001) microstructures with a high sensitivity, even for small misalignments of both magnetic electrodes. The angular dependence of the hot-electron magnetocurrent is used to convert magnetization maps calculated by micromagnetic simulations into simulated BEMM images. The calculated BEMM images and magnetization rotation profiles show quantitative agreement with experiments and allow us to investigate the magnetic phase diagram of these model Fe(001) microstructures [2]. Finally, magnetic domain reversals are observed under high current density pulses. This opens the way for further BEMM investigations of current-induced magnetization dynamics.



*1400*1400nm^2 STM image (a) and corresponding BEEM image (b) of a nanostructured stadium-shaped Fe/Au/Fe/GaAs(001) spin-valve. Note the presence of 4 magnetic domains in the Fe nanostructure. OOMF micromagnetic simulation of the 4 domains state (c) which was used to simulate (d) the experimental BEEM image.*

[1] M. Hervé et al., *Applied Physics Letters* **103**, 202408 (2013)
[2] M. Hervé et al., *Journal of Applied Physics* **113**, 233909 (2013)